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Interface Friction

by: George Yazdani, P.E.

Interface friction angles are used for stability calculations. Several tests may be required to obtain the friction angles for all interfaces in a liner system. Each test costs approximately $500. The cost is usually higher for testing soils next to synthetic material, if the soils have to be conditioned. The friction behavior between soils and geosynthetics is influenced by a number of variables which are as follows:

Friction Test Variables

There are several different test methods, such as direct shear, torsional shear, and inclined tables, which often produce different results. The industry standard test method is ASTM D 5321, **Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method**. The test device is a direct shear box measuring 12" x 12". The liner is clamped to the lower stationary box which is longer than the upper box to allow total area contact between the two material during the test. The soil is placed and conditioned in the upper box. A compressive normal load is uniformly applied to the soil. The upper box is moved at a constant rate over the lower box. The shear force which is required to pull the box is measured for three different normal loads. The data is plotted to represent a line on a normal stress verses shear stress graph. The angle of this line with the x-axis is the interface friction angle.

Other variables related to test material and conditions are highlighted below.

- Soils type; gradation, particle size and shape, and plasticity (cohesion)
- Soils moisture content, density, and drainage during testing
- Liner surface condition; shape, size or amplitude of textured surface
- Machine or cross machine direction of textured liners, geonets, and geotextiles
- Normal load and shear displacement rate
- Testing accuracy and errors

A combination of these variables resulted in different friction angles between the same materials as shown below.

Interface	Variation in test results
Textured HDPE/Ottawa sand	21%
Textured HDPE/Kaolinite clay	91%
Smooth VLDPE/Geonets	15%
Textured HDPE/Geotextiles	44%

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The variations in test results are based on a small number of tests, and may be larger for a higher number of tests. This would cause a contractor to be reluctant to certify to any values prior to having the tests performed under the given condition by a reputable laboratory.

Friction Data

The following data represent peak interface friction angles which may be expected for the specified materials. Site specific tests should be performed, under the direction of the project engineer by a reputable laboratory, to evaluate all interfaces of a proposed liner system. **The following interface friction data should be used for general information purposes only, and should not be used for design or certification purposes.**

Material in contact with a Poly-Flex Textured Polyethylene Liner	Interface Friction Angle
Ottawa Sand	28°
Silty Sand with Clay	32°
Composite Geonet (Geonet side)	17°
Composite Geonet (Nonwoven geotextile side)	25°
Nonwoven Geotextile	26°
Geosynthetic Clay Liner (Woven geotextile side)	33°

Each test is for a specific textured liner under a specific test condition.

Bidding Strategy

Most project specifications require that the contractor certify that his proposed material meet the specified friction angle(s) at the time he bids the job. This would require the contractor to do one or more tests with geosynthetics and/or site specific soils which are often not identified or available prior to bid opening. Even if the materials were available, most contractors and manufacturers would not spend hundreds or thousands of dollars to run these tests before they get the job. It is important to clarify this matter by adding a statement similar to the following to the proposal.

"The interface friction tests, if required, should be performed by the Owner [at his expense]. Friction test results are highly dependent on the test material, procedure, and conditions. Poly-Flex Construction, Inc. [Approved Contractor] cannot certify to any friction values prior to obtaining satisfactory test results for the site specific material and test conditions from a reputable laboratory. Test material, method and conditions should be specified by the project engineer."

Please feel free to contact me at (800) 527 3322 or (214) 647 4374, extension 314 if you should have any questions regarding this topic.

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FRICTION TEST RESULTS FOR POLY-FLEX AND DURA-FLEX SMOOTH AND TEXTURED LINERS NEXT TO SOILS AND OTHER GEOSYNTHETICS.

MATERIAL	HDPE	VLDPE	HDPE-R	VLDPE-R
Ottawa sand, MC=5% 4			(38°)	
Dry Ottawa Sand 18"x18" 1		19°		
Wet Ottawa Sand 18"x18" 1		17°		
Wet Ottawa Sand 3				25°
Wet Ottawa Sand 4				25°
Wet Ottawa Sand 4			34°(33°)	
Wet Ottawa Sand 3			29°(29°)	
Wet Ottawa Sand 3			28°(25°)	
Wet Ottawa Sand 2			30.6°(24.5°)	
Wet Ottawa Sand 2				36.9°(32.9°)LLT
Dry Concrete Sand 18"x18" 1		21°		
Wet Concrete Sand 18"x18" 1		21°		
Dry Concrete Sand 18"x18" 1			30°	
Sat. Sand 2.36" Dia. 5		27°		
Sand & Gravel 4		11°		
Dry Sand (4"x4") 1		31°		
Dry Sand (4"x4") 1	22.5°			
Dry Sand (4"x4") 1			46°	
Kaolinite Clay 18"x18" 1			11°	
Kaolinite Clay 4"x4" 1		6.5°		
Kaolinite Clay 4"x4" 1			21°	
Wet Select fill 3				39°(32°)
Low perm soil 2			43.7°	
Soil/bentonit 4		24°(21°)		
Wet random fill 3		20°(20°)		
Wet random fill 3				32°(32°)
Tensar DN4 net 4		15°		
Tensar DN4 net 18"x18" 1		15°		
Tensar net 3		13°(12°)		
Serrot J-Drain 200N 6		8°(7°)		
Tensar Composite net (tex side) 18"x18" 1		19°		
Tensar DC 4205 4			30°(19°)	
Tensar DC 4205 Wet 4				25°(25°)
Wet Tensar DC 4205 2			31.8°	
TN3002 Composite net 3				39°(26°)
TN3001 Composite (net side) 3		11°(11°)		
TN3001 Composite (net side) 3				17°(14°)
Supac 8 NP Tex Wet 4				25°(25°)
Supac Tex 4			18°(20°)	
Supac 8NP Tex 4			26°(26°)	
Spartan 16 Oz Tex 2			32.5°	
Typar 3601 4	21°(14°)		20°(20°)	
Hyd. Bentomat (Wov tex) 3		15°(15°)		
Hyd. Bentomat (Wov tex) 3				33°(24°)
Hyd. Bentomat (Wov tex) 7			9°(8°)	
Hyd. Bentomat (Nonwoven text) 7			2°(2°)	

Values in ( ) indicate the residual friction angles.
Data compiled by George Yazdani, P.E.

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1 Geosynthetic Research Institute (GRI)
2 Texas Research Institute (TRI), 0.7, 1.4, 3.5 psi normal stress
3 Geosyntec Consultants
4 Westinghouse Environmental and Geotechnical Services
5 Klohn Leonoff Engineering, 2.4" Dia box, 20, 45, 70 psi normal stress
6 Vector Engineering, 2, 4, 6 psi normal stress
7 Killam Associates, 56, 97, 139 psi normal stress

GRI tests for Ottawa and concrete sand, geonet and composite net next to smooth VLDPE were done under 5, 10, 15 psi for HDPE and 3, 6, 9 psi for VLDPE

Westinghouse tests for DC 4205 composite net and 8 NP geotextile were done under 5, 10, 15 psi

Westinghouse tests for bentonite amended soil and DN 4 geonet were done under 27.8, 59.7, 97.2 psi.

Westinghouse tests for Typar 3601 were performed under 6.9, 13.9, 20.8 psi

Geosyntec tests for wet Ottawa sand and HDPE-R were done under 10, 40, 80 psi

Geosyntec tests for wetted TN3001 (net side) and hydrated Bentomat (woven side) next to smooth and textured VLDPE were done under 0.35, 1.4, 2.8 psi

GRI tests for dry sand and smooth VLDPE and HDPE and textured HDPE in 4" x 4" shear box were done under 4.5, 9.0, 18.0 psi

Geosyntec tests for random fill and VLDPE were done under 0.35, 1.4, 2.8

The TRI test for textured HDPE was performed under 1, 5, and 10 psi normal stresses.

The TRI test for textured LLDPE was performed under 1, 3, and 5 psi normal stresses.